Analysis of Activity of Taiyangshan Fault Zone in Western Margin of the Dongting Basin

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Abstract

The Dongting down-warped basin is a Cenozoic rift basin, whose tectonic structure and evolution history are far more complex than other basins in the region, with its relatively strong new tectonic activity and earthquake activity, and relatively strong movements of disparity reflected by the uplift of Taiyangshan in the western margin of the basin. To separate the east Changde down-warped basin from the west Lishui down-warped basin, thus forming the zone with the most intense activity of disparity since the neotectonic in the region, which equips with the tectonic setting of strong earthquake. Taiyangshan region has historically occurred strong earthquakes and moderate strong earthquakes such as in 5-magnitude earthquake in 1516, 6 3/4-magnitude and 5 3/4-magnitude earthquake in 1631 and 5-magnitude earthquake in 1906 and so on. This paper makes further inquiry on the distribution of Taiyangshan fault zone and its activity, which has practical significance for the understanding of seismogenic structures and seismic hazard analysis in the region.

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1. Introduction

Dongting basin is a Cenozoic rift basin, whose margin has some differences in some aspects as the movement strength of new tectonic, fault activity and the level of seismic activity and so on, especially the strong movements of disparity reflected by the uplift of Taiyangshan region in the western margin of the basin to separate the east Changde down-warped basin from the west Lishui down-warped basin, thus forming the zone with the most intense activity of disparity since the neotectonic in the region. In this region it has historically occurred strong earthquakes and moderate strong earthquakes such as in 5-magnitude earthquake in 1516, 6 3/4-magnitude and 5 3/4-magnitude earthquake in 1631 and 5-magnitude earthquake in 1906 and so on. However, due to the Quaternary in the region covering a large area while with very little outcrop, it has brought a lot of difficulties to the seismogenic structure of the region's determination. In recent years, with such work as the Hunan Province earthquake seismic zoning, siting of
nuclear power plants and so on to be carried out, we have done a lot of field research and field exploration work in the area and had achieved some new information and new understanding. Based on the previous study, this paper makes investigation and study on the tectonic setting of the western margin of the Dongting basin and distribution and activity of the important causative structure in the region- Taiyangshan fault zone, which provides basic information seismic hazard analysis in Dongting basin and the region around and pre-compilation work of seismic zoning in the region of Hunan.

2. Dongting Basin Regional Tectonics Background

Dongting Basin lies in the second subsiding belts of the new cathaysian system. The basin of the part belonging to the southeast low-lying areas is part of is bounded on the north by the uplift of Huarong and separated from Jianghan Basin by a "mountain". The eastern boundary is limited to Chongyang - Ningxiang fault, to the south of Xuefeng Uplift, and connected to the west of rift of Taoyuan - Linli - Li County, which through the fault communicates Jianghan basin to the north extension.

Dongting basin was formed in the late Yanshan, the strong fault location in the arc Xuefeng Uplift. In the overall settlement process, each part has performed the obvious differences, forming a series of faults mainly North-East-oriented and North-Northeast-oriented, and the secondary bulge and fault controlled by these faults in the same direction.

The basin in the Mesozoic and later tectonic movements has experienced a left-right line of the knob movement, resulting in three bump and shallow zones relatively uplifted and fault separated by the North-East base fracture in the basin, where are Taoyuan fault depression, Taiyangshan Salient, Changde fault depression, Muping Lake Salient, Yuanjiang depression, Mahekou Salient and Xiangyin fault depression from west to east.

3. Taiyangshan Regional Tectonic Setting and New Tectonic Movement Features

Taiyangshan region is located in west of Jianghan-Dongting Lake depression, and with the North-Northeast-oriented trending Taiyangshan uplift to separate the east Changde down-warped basin from the west Lishui down-warped basin, thus forming the zone with the most intense activity of disparity since the neotectonic in the region which equips with the tectonic setting of strong earthquake. In the Taiyangshan uplift, the southwest of Taiyangshan uplift tilting uplift to the North-Northeast-oriented tilting; northeast of the Fenghuangshan uplift tilting uplift to the South-Southeast-oriented tilting and the two activities of uplift tilted have the characteristics of campaign of hub.

The uplifted area of Taiyangshan is an uplift of the hilly area during the Cenozoic. Hill takes the shape of North-Northeast-oriented trending, about length of 30km and width of 15km, standing in the western margin of Dongting Basin, constituting a strong topographic contrast. There is a distribution of the Taiyangshan uplift and the Fenghuangshan uplift and the Dalongzhan Valley from south to north in the right-echelon. The maximum altitude of the Taiyangshan uplift is 560m, reducing gradually along the North-Northeast-direction and connected as a single entity with the rift Dalongzhan Valley. The maximum altitude of the Fenghuangshan uplift is 378m, reducing gradually along the Southwest -direction, with the southern Liuye Lake dropping to about 35-40m above sea level. To see from the new features of tectonic movements in the Taiyangshan region, this region shows the new tectonic movements forms of the characteristics of the hub block activity as a whole.

4. Taiyangshan Fault Zone

This fault zone is located in the uplifted area of the western margin of the Dongting Lake depression, with the performance of fault zone composed of series of the North-Northeast-oriented fault, distributing six
main surface faults as Gangshi-Hefu, Shichaipo, Xiaowupu, Xianfengyu, Yangpochong and Chimashan in the east and west sides and the central of the Taiyangshan (Figure 1).

With the comprehensive analysis of previous research data, Gangshi-Hefu fault (F1) is an active fault in the early and middle Pleistocene; Shichaipo fault (F2) is exposed to the west foot of the Taiyangshan, according to the fault material and coating well testing yearly data, the initial judge is the former Quaternary fault. Xiaowupu fault (F3) is distributed along the eastern edge of the Dalongzhan Valley, fracture the Pleistocene clay, clay and gravel folder, initially to determine there have been activities at least in the late Pleistocene. Xianfengyu fault (F4) is located in the eastern side of the Taiyangshan, the former Quaternary active fault, but does not rule out the activities in the early Pleistocene. Yangpochong fault (F5) is located in the Fenghuangshan region, to the North-Northeast is the former Quaternary active fault, do not rule out activity in the early Pleistocene. Chimashan fault (F6) is located in the side of the road from Linli to Jinshi, without deformation of breaking overlying slope sandstone and gravel layer, the TL dating of the bottom layer (8.66 ± 0.74) ten thousand years (Institute of Geology, China Earthquake Administration, 2004). From the analysis results, in the various branches of fault in the Taiyangshan fault zone, Xiaowupu fault (F3) has clear geological and geomorphological performance, which is a fault of relatively late activity.

From the north of the uplifted area of the Taiyangshan in the area to the west of Changde-Yiyang-Changsha fault zone is the fourth fault coverage, by studying relationship between the NNE Taiyangshan fault zone and the Quaternary strata, you can effectively obtain evidence about the active time and amplitude of fault zone and other aspects of evidence. For this reason, we laid the survey line (WT6) (Figure 1) of a total length of 15km. From west to east there are 7 survey lines to be completed and with the distribution WT6-1 (3242m), WT6-2 (1366m), WT6-3 (1622m), WT6-4 (1710m), WT6-5 (1522m), WT6-6 (3646m) and WT6-7 (1902m). After the detailed interpretation of reflected wave segment time profile of 7 survey lines, we can determine only in the most eastern section WT6-7 there was an apparent breakpoint which is in the extending southward position of the Xiaowupu fault (F3).

Figure 1 detection profile figure of Taiyangshan Fault Zone
4.1 Detection Profile of WT6-7 Survey Line.

WT6-7 survey line lies in the rice fields to the north of WT6-6 survey line by 100m, whose direction is North-West-oriented, at the length of 1902m. When WT6-6 survey line is passing by a breakpoint FP4, because of the influences of houses, roads, drains and other surface obstructions, then the features of the breakpoint FP4 in the detection profile of WT6-6 survey line are not very clear, therefore, when making the layout of WT6-7 survey line, the western end of this survey line overlap with the eastern end of WT6-6 survey line around 550m, in order to further determine the reliability of the breakpoint FP4 in WT6-6 survey online. The time detection profile of the reflected wave superposition and the profile of depth interpretation of WT6-7 survey line are shown in Figure 1.4-6. Based on characteristics of detection profile, 3 groups of surface reflected waves of T01, T02, and TQ with significant features are explained in the detection profile, where the reflected wave of TQ is from the bottom boundary of the Quaternary covering layer, it was horizontally distributed to the east of profile stake by 600m, with relative little ups and downs; between stake 250 ~ 550m there is a significant uplift area in the bedrock; the buried depth of rock surface of the area this survey line goes through varies about 50 ~ 80m depth. Reflected wave T01 and T02 are from the Quaternary physical interface reflection within, with the buried depth of reflected wave of T01 50 ~ 60m, sloping from west to east in general, the occurrence of reflected wave T02 is close to the level, and its buried depth is about 26 ~ 28m. We can see from the energy change and the lateral continuity of the reflected wave of TQ in the WT6-7 profile that in the profile stake about 110m, the reflected wave of TQ appears significantly wrong show and also in the vicinity of the wrong breakpoint appear reverse tilt reflection and arc diffraction wave, according to the analysis on these phenomena, there would exist the fault FP5 of a break of about 1 ~ 2m away in the stake 110m. For clarity, the WT6-7 survey lines across the waveform of FP5 breakpoint plus variable area are expanded in Figure 2. Figure 2 shows very clearly the off-axis phenomenon with the reflected wave occurring in the vicinity of FP5 breakpoint.

![Profile figure of reflected stack and interpretation of shallow earthquake of WT6-7 survey line](image)

4.2 Drilling Joint Detection Profiling of WT6-7 Survey Line.

Drilling Layout. In order to identify the activities of FP5 breakpoint and the thickness of the Quaternary on both sides of the breakpoint, in the WT6-7 survey line, the drilling joint detection profile was made across the breakpoint FP5. Drilling site is located in two rice fields with the height difference of 0.3m, among which SQZH1, SQZK2 and SQZK3 drilling hole are located in the higher rice field, and the remaining two drilling holes in the lower rice field (Figure 3).
Table 1.4-3 Table of depth of drilling hole, bedrock buried depth and spacing of holes of WT6-7 survey line

<table>
<thead>
<tr>
<th>Drilling hole No.</th>
<th>Height relative to SQZK1 /m</th>
<th>Hole depth /m</th>
<th>bedrock buried depth /m</th>
<th>spacing of holes /m</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQZK1</td>
<td>0</td>
<td>50.3</td>
<td>48.7</td>
<td>20.5</td>
</tr>
<tr>
<td>SQZK2</td>
<td>0</td>
<td>50.6</td>
<td>48.5</td>
<td>10</td>
</tr>
<tr>
<td>SQZK3</td>
<td>0</td>
<td>52.5</td>
<td>48.2</td>
<td>15</td>
</tr>
<tr>
<td>SQZK4</td>
<td>-0.3</td>
<td>90.0</td>
<td>49.4</td>
<td>20</td>
</tr>
<tr>
<td>SQZK5</td>
<td>-0.3</td>
<td>52.5</td>
<td>48.3</td>
<td></td>
</tr>
</tbody>
</table>

Strata revealed by drilling joint geological detection profiling. Compared with the distribution of Quaternary strata, stratigraphic features, deposition thermo luminescence dating (TL) and bio-stratigraphic chronology analysis (pollen analysis) of Dongting Lake area, the Quaternary strata revealed by drilling joint geological detection profiling of Shuangqiao are Holocene Strata, the late Pleistocene and the Pleistocene Strata. Under the Quaternary strata are the Neogene mudstone and interlayerd bedding sandstone. The characteristics of the strata top-down are described as follows:

1. Quaternary Holocene ($Q_h$): Mainly gray, blue gray, grayish yellow silty clay, silt;
2. Late Quaternary Pleistocene ($Q_p^3$): The lower part is gray, light gray clay, gravel layer of sand filling. Gravel content of more than 50%, the diameter is generally 2-7cm, a small amount greater than the diameter of hole. Mostly sandstone has gravel composition, which is hard. Folder is thin carbonaceous clay; upper part is gray, grayish yellow fine sand, silty clay; OSL dating result is 42-120 thousand years ago.
3. Middle Quaternary Pleistocene ($Q_p^2$): Brown coarse gravel layer with gray thin grayish fine sand and clay folder, with buried depth of 44-48m. OSL dating result is 120-170 thousand years ago.

5. Analysis Results of Activity of Fault

From the drilling joint geological detection profiling (Figure 4), we can see the bottoms of Holocene gray, grayish yellow silt, silty clay layers are at the same height roughly, with the buried depth of 11m or so. Late Pleistocene layer is a thick pebble layer of gray sand, usually with the diameter of 20-50mm, some pebbles are greater than the hole in terms of diameter, that is greater than 100mm. Pebbles are mainly black Gui rocks and purple-red sandstone, with good roundness. The filling materials between pebbles are gray clay.
and sand. The bottom is of beige, pale yellow clay, silt and silty clay. The top is near to the level, not impacted by factors of fault movement.

From the drilling joint geological detection profiling (Figure 4), we can see the Neogene top gap of SQZK3 and SQZK4 holes is 1.5m, with two angles of 50° and sliding surface associated with the fault found in the Neogene of the hole of SQZK4, which were all shown for the normal fault slip properties. So that we can confirm that there exists a Neogene normal fault between the holes of SQZK3 and SQZK4. In the bottom of the Pleistocene and the top of middle Pleistocene there is a set of beige, gray clay and silt layer interlayer, the interlayer appears in the holes of SQZK5 and SQZK3, and the gray silty clay also appears in the bottom of the hole of SQZK4, the age of deposition is 120,000-170,000 years ago, the top is in the same depth in general, with the overall performance of the high west and the low east, being consistent with the ancient flow of water. Xiaowupu fault did not affect the occurrence of the top surface of the fine sediment. The fault has been updated the Pleistocene gravel and clay layer in the wrong breaking in the area of Taiyangshan to the north of the city of Changde (Institute of Geology, State Seismological Bureau, 1990), thermo luminescence era of normal fault gouge dating samples of the North-east-oriented fault sand in the same place is 60 thousand years ago (Institute of Crustal Dynamics, State Seismological Bureau, 1986).

From the comprehensive analysis we can see that the two activities of the Taiyangshan fault zone in a relatively new era, Gangshi-Hefu Fault and Xiaowupu Fault are in the southern study area, located on east and west side of Taiyangshan. This shows that the tectonic activity in the south of the area is more intense than in the north, which the sun and landscape mountain uplift on the south, which is consistent with the trend of the south being higher than the north of the uplifted Taiyangshan in the landscape. The latest eras of activity of the Taiyangshan fault zone is the Middle Pleistocene to Late Pleistocene, which can be determined the controlling structure in the region, that is, construction of earthquake control in Changde earthquake.

![Figure 4](image)

Figure 4 Figure of drilling joint geological profiling of WT6-7 survey line
(Center of Exploration Geophysics, China Seismological Bureau, 2008)
References


